REMOTE SENSING CENTER GRANT PROGRAM SUMMARY

NASA GRANT NGL 44-001-001

PROGRESS REPORT
August 1, 1974 - February 1, 1975

supported by
National Aeronautics & Space Administration

TEXAS A&M UNIVERSITY
REMOTE SENSING CENTER
COLLEGE STATION, TEXAS

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1-a

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TABLE OF CONTENTS

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SUMMARY

The objective of the six-month program reported in this Summary was to focus the efforts of the NASA Grant projects of the Remote Sensing Center on concise demonstrations of the remote sensing techniques and technology developed at Texas A&M University. Several of these projects are documented in the opening section of this report in a format which states the basic *Concept*, *Procedure*, *Results*, and *Payoff* in a succinct manner. The most significant of these demonstration projects are also being prepared as slide presentations in 35 mm format with accompanying text.

This Summary also discusses the Applications and Supporting Technology activities of the Grant Program from which the Demonstration Projects have evolved. It is important to note that during this six-month effort the Supporting Technology activities have been deemphasized and are expected to be completely discontinued in the subsequent Grant Program effort. During this report period, several publications

dealing with Grant Program activities have been completed. These are listed in the final section of this report.

DEMONSTRATION PROJECTS

ENFORCING THE QUARANTINE OF DISEASED CROPS

Concept

St. Augustinegrass is the primary turf used for lawns and pasture throughout the South. Ninety-six percent of the lawns along the Texas Gulf Coast are St. Augustine. This turf grass was attacked by a strain of Panicum Mosaic Virus, termed St. Augustine Decline (SAD), beginning in the mid-1960's. The damage caused by the virus has been extensive to both homeowners and commercial growers in Texas. Consequently, the Texas Department of Agriculture (TDA) has quarantined all commercial farms pending development of a SAD-resistant grass species. The quarantine has been costly and only partially successful. The TDA spends in excess of $10,000 each year just to survey the diseased crops. The manual survey process requires more than six weeks to complete. An improved survey technique and a more effective quarantine enforcement procedure was needed. It was hypothesized that remote sensing techniques could assist with this state problem.

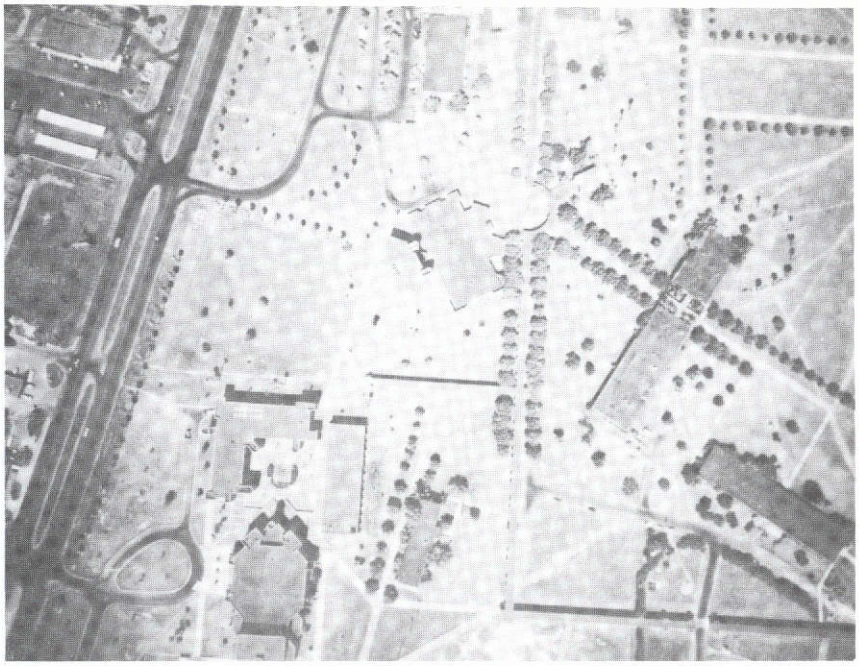
Procedure

A project was initiated by the Remote Sensing Center in cooperation with the Johnson Space Center to determine a remote sensing technique for the early, reliable detection of SAD virus symptoms. Greenhouse samples, test plots, and commercial fields were measured. Initial results of both spectrophotometer and spectroradiometer readings indicated little spectral signature differences between healthy and diseased grasses. However, the use of light polarizers showed significant differences in light reflectance in both the red and blue portions of the spectrum.

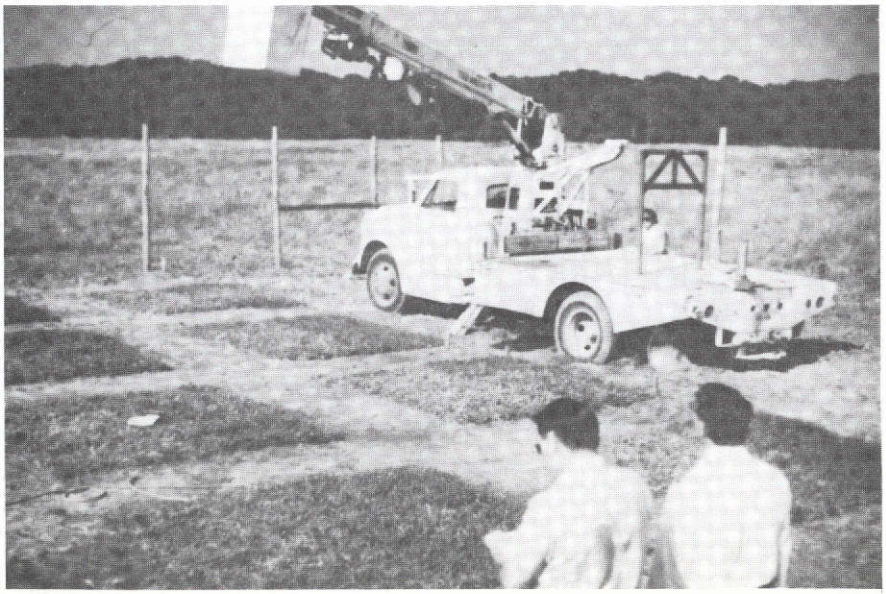
The aerial detection method subsequently developed consisted of four Hasselblad cameras with polarizers using Plus-X film with red, green, and blue filters and black-and-white infrared film with an 89B IR filter.

Results

During the spring of 1974, the Texas Department of Agriculture requested that the Remote Sensing Center fly a SAD detection mission over commercial fields in the Weslaco-McAllen area of Texas. The area included farms that were known to have SAD infested crops. These farmers had been



ST. AUGUSTINE DECLINE - Pan American University Campus, lawns infected with St. Augustine Decline. Diseased areas are detectable and intensities differentiable on the original color transparency.



3-a

ST. AUGUSTINE DECLINE - NASA truck-mounted spectroradiometer measuring control plantings of SAD-diseased and healthy turf.

requested by TDA to plow under the diseased areas. However, the farmers had not been responsive to the request and the TDA Quarantine Division was aware of attempts to illegally harvest and ship some of the diseased turf. The farmers were notified by letter from the TDA that their farms would be overflown during March 1974 for the purpose of remote sensing SAD infected areas. On March 4, 1974, just prior to the scheduled flights, a visual inspection of the suspect commercial farms confirmed that all SAD infected grass areas had been voluntarily destroyed by the farmers.

Payoff

Whereas the commercial turf grass growers in Texas realized that the existing manual inspection techniques of the TDA were inadequate to enable TDA to properly enforce the state-wide quarantine, the advent of an aerial remote sensing technique convinced the growers that the quarantine could be effectively enforced and, hence, they chose to comply with the TDA regulations.

As a result of this Grant Program activity, the Texas Department of Agriculture now has availiable a reliable, cost-effective remote sensing technique for surveying and enforcing quarantine restrictions on the Texas turf producers.

IMPROVING VEGETATION UTILIZATION IN URBAN PLANNING

Concept

The Federal Government has authorized the development of certain entirely new planned communities as an experiment in urban planning with minimum environmental impact. The Woodlands is one of these Title VII communities located 28 miles north of Houston, Texas in Montgomery County. In preparation for this development, Mitchell Associates began compiling extensive background information on the 17,776 acre construction site. This included geologic, topographic, water resources, and soil maps and surveys of wildlife resources. These data were formatted as a series of thematic maps and overlays. An attempt was made to acquire sufficient vegetation information using ground survey techniques in order to supplement these maps. However, it was found that because of the quantity and quality of vegetation information required to support the project planning activities, the ground survey methods were inadequate. It was hypothesized that aerial remote sensing techniques would be used to provide satisfactory vegetation species identification and vegetation distribution maps more rapidly and at less cost than existing methods. Mitchell Associates agreed to fund a portion of the procedure developments costs.

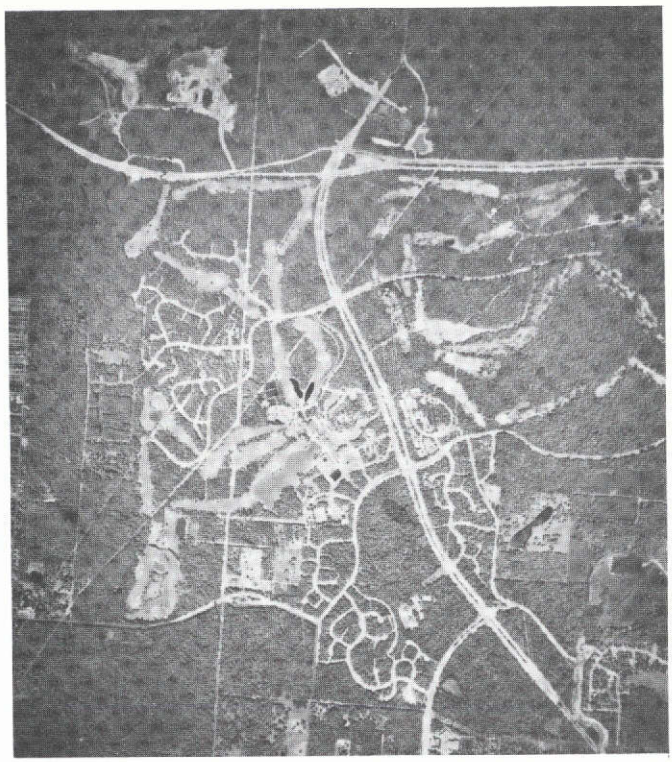
Procedure

The nature of the information required dictated that a ground survey approach must be employed during the initial stages. The objective of the remote sensing procedure developed was to optimize the ground survey and considerably reduce the intensity of the ground sampling. This was accomplished by employing a photo interpretation grid-sampling procedure with color and color infrared photography acquired at a scale of 1:6000. Tests with black and white film and with several grid-sampling methods were conducted prior to developing an acceptably reliable approach.

Results

Color and color infrared photography was used to prepare vegetation maps of critical portions of the Woodlands construction sites. The maps showed location, species, size, and relative health of the vegetation in the area. Ground sampling was substantially reduced, and it was found that an extension of the technique to new areas could be done reliably with virtually no ground verification. A series of vegetation maps were constructed using sequential photography.

The sequential photos proved to be useful in recording construction progress and the impact of construction activities on the vegetation. The definition



THE WOODLANDS - Initial development area, showing vegetation types, recreational facilities and cultural features. (Black and white reduction for color infrared transparency).

THE WOODLANDS - Section of vegetation - cultural map made from color infrared photos.

obtainable from the 1:6000 scale photos allowed examination of individual trees and clumps of underbrush. This gave the developer insight into the undesirable environmental effects of common construction practices. To this end, the developer evolved a system of protective fences and barricades to prevent trees from being barked, shrubs from being overrun, and root systems from being overcompacted. In certain cases, subcontractors were taken off the project because of damage they had done to the vegetation.

Payoff

The vegetation maps prepared by the Remote Sensing Center were incorporated into the construction planning documents for the Woodlands. These data were used to select the locations of commercial buildings, homes, and roads within the site. The specific benefits obtained as a direct result of the use of these vegetation maps included:

- reduced landscaping costs due to the extensive utilization of the natural vegetation.
- reduced need for artificial drainage systems because of the maintenance of natural ground cover in select areas.
- increased land value and greater profit per acre of development due to limited construction-related environmental degradation.

The remote sensing procedure developed offers the additional advantage that environmental damage due to urbanization can be monitored in a rapid, cost-effective manner. The general methodology developed in this NASA Grant project has been adopted by the Woodlands developer for his future urban planning activities.

ASSISTING AQUATIC PLANT MONITORING AND CONTROL

Concept

The infestation and rapid growth of aquatic plants in Texas reservoirs has become a serious state problem. These plants have adverse effects on navigation, flood control and drainage, fish and wildlife, recreation, public health, and water quality. The growth and spread of these plants is so dynamic that it has been impossible to monitor and control the infestation by conventional means. The Texas Parks and Wildlife Department, with major funding assistance from the Corps of Engineers, has initiated systematic chemical spray programs costing over $50,000 annually in an effort to eliminate the problem (over $300,000 total expenditure in Texas to date), but the program has been only marginally successful and the aquatic infestation is still spreading each year within affected lakes and into new lakes. It was hypothesized that use of remote sensing

techniques could aid in monitoring the species type and growth rate, and in determining more optimum periods and locations for application of chemical sprays.

Procedure

Color and color infrared photography was selected as the basic sensing technique, however, it was determined that processing control had to be far more stringent than in most work with this approach. Repeated flights over an extensive aquatic plant region of Lake Livingston in east Texas were performed, with supporting ground observations, to develop acceptable flight parameters, exposure settings, film processing procedures, and interpretation guides. Signatures of surface species were shown to provide adequate differentiation, however species such as hydrilla, coontail, and myriphyllum, which have both submersed and emersed states, often require temporal data to insure discrimination when submersed. The procedure established requires careful control of the sensing technique and use of sequential photography throughout the growing season.

Results

The sequential photography showed that there is no single period of youth, maturity, or senescence in the aquatic plants in Texas lakes. Newly emergent areas continually appear, even in mid-to-late season, both on the

AQUATIC PLANT MONITORING - Lake Livingston, Texas; east end of Jungle area, showing old river channel at right. Area to right of channel is land; area to left is water covered by water hyacinth and duckweed. (Black and white reduction of color infrared transparency).

9-a

AQUATIC PLANT MONITORING - Entrance to Beacon Bay Marina. Cloudy patches offshore are areas of hydrilla infestation. (Enlargement of color infrared transparency).

fringes of mature patches and in completely new areas of the lake. In the case of water hyacinth, new areas of youthful activity reoccur in areas where the mature plants have been sprayed with chemical herbicide. These findings account for the lack of success often experienced with the present herbicide application program.

Sequential imaging showing the effects of herbicide stress indicated repeated patterns of distinct stress bands, dieback, occasional disappearance of the vegetation mat, reemergence of the youthful plants, and steady and vigorous regrowth in the sprayed areas.

The findings included the following:

- Aquatic plants in Texas lakes are very dynamic systems.
- The seasonal evolution of aquatic plants can be monitored by remote sensing techniques. An estimate of aquatic plant biomass may be feasible.
- The maximum value of the remote sensing approach may be in the accurate monitoring of the effects of chemical herbicide treatments (and probably biological control agents as well) on plant status and regrowth.

- Evidence was found that application of the herbicide 2,4-D in the concentrations presently used may be counterproductive for long-range plant control.
- ERTS imagery is useful in monitoring seasonal growth of hyacinth and duckweed in large lakes with known infestations.
- Hydrilla, a particularly noxious aquatic plant species, has been identified on color and color infrared photography and is now known to exist in Lake Livingston.

Payoff

The imagery collected as part of this NASA Grant project has been discussed with the Trinity River Authority, Texas Parks Department, Texas Water Quality Board, and EPA. Representatives of these agencies were advised of the documented dynamic proportions of the aquatic plant problem in Texas lakes and of the evidence found that the current control program was inadequate to eliminate the spread of these plants. One of the agencies responsible for the control program in Lake Livingston, the Trinity River Authority (TRA), reevaluated their approach and have adopted a systematic

remote sensing survey of the lake for their 1975 season plant control program. The technique developed in this NASA Grant project will be employed during 1975 by Texas A&M University under contract to the Trinity River Authority. These data will also be employed by the Texas Parks and Wildlife Department as part of their chemical spray program. The 1975 work is a pilot project for subsequent application of the approach to other lakes in Texas.

CONTINUOUS AREA SURVEILLANCE OF OIL SPILLS

Concept

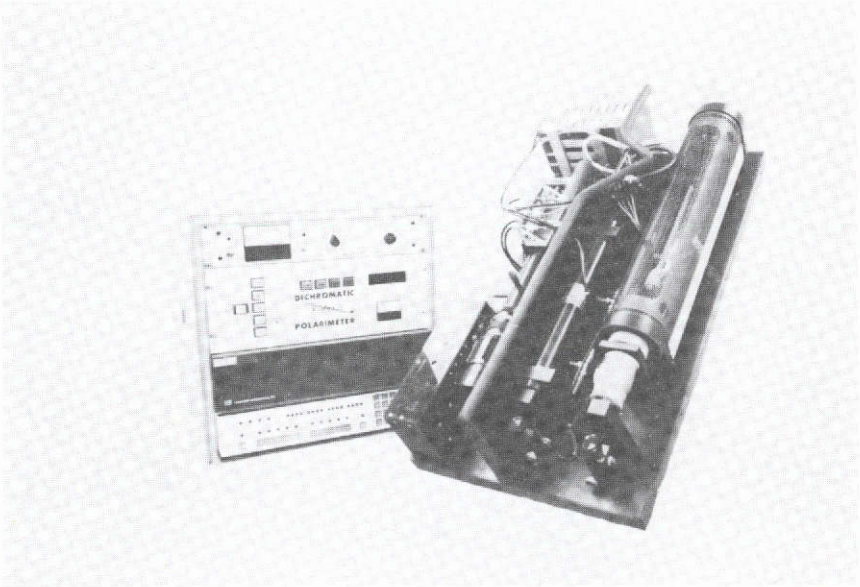
The federal Water Pollution Control Act Amendments of 1972 requires the U.S. Coast Guard and the Environmental Protection Agency to monitor and enforce regulations pertaining to the discharge of oil and hazardous substances into the nation's waterways. Each of these agencies have investigated various techniques, including several remote sensing methods, to aid them in minimizing environmental damage from such discharges and to effect prompt containment and cleanup efforts. Remote Sensing Center personnel conceived and developed a completely new and unique remote sensing technique which was thought to be adaptable to the oil spill detection problem. A NASA Grant project was initiated to confirm the applicability of the new technique.

Procedure

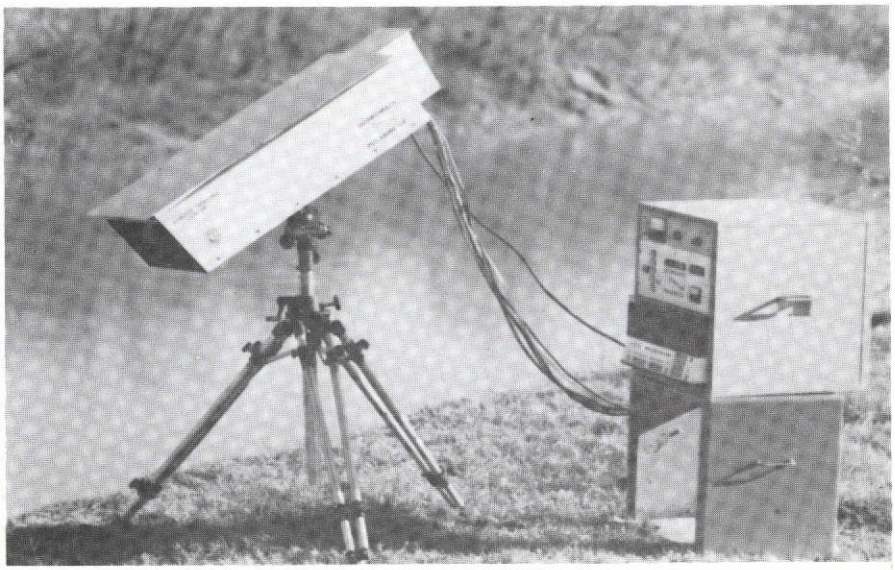
During the course of an examination of radar backscatter measurements as part of a NASA Grant microwave remote sensing project, a new concept for describing the scattering of electromagnetic energy from rough surfaces was developed. A crude test setup was assembled using a helium-neon laser to test the new hypothesis. Backscatter measurements with this equipment established that the principal contribution to the depolarization of electromagnetic energy incident on inhomogeneous rough surfaces was due to a subsurface volume scatter mechanism. This realization caused a significant change in the interpretation of radar sensor measurements and opened a wide new area of applications for both radar and laser sensors. One of these was the rapid, accurate measurement of suspended particles in water (turbidity). A simple extension of this potential showed the applicability of the technique to oil spill detection. A further extension indicates the potential for detecting hazardous chemicals in water; a potential which is yet to be tested.

Results

The NASA Grant project was extended to include measurements of laser backscatter from turbid water and



OIL SPILL SURVEILLANCE - Lidar Polarimeter, control console on left, transceiver at right.



13-a

OIL SPILL SURVEILLANCE - Lidar Polarimeter test on river bank.

from oil spills on turbid water. The results confirmed the initial expectation that the concept was applicable to the oil spill problem.

The results were presented to the U.S. Coast Guard who recognized the value of the technique in their proposed Transportation Induced Pollution Surveillance (TIPS) System. They authorized funding (approximately $100,000) to enable further development and testing of a prototype sensor system employing the new laser technique. This system, the Dichromatic Lidar Polarimeter, is presently undergoing testing on waterways in Texas. The Coast Guard has also approved funding (approximately $100,000) for a second phase of the effort to develop a second generation of the device which is expected to be the prototype of a system for eventual installation in the nation's ports and harbors.

Payoff

From this NASA Grant project a new interpretation of electromagnetic backscatter was developed that has significantly altered the analysis of microwave remote sensing data and has led to a major new sensing technique directly applicable to a problem of natural concern: oil spill

detection. The NASA Grant is directly responsible for the development of this new technology, and this project is an excellent example of the orderly evolution of a basic idea to a technology satisfying a current natural need.

EVOLVING DEMONSTRATION PROJECTS

The following demonstration projects are rapidly approaching the stage when the associated remote sensing technique will be adopted for systematic use by the agencies involved. That is, at this date the Payoff aspect is not firmly established, but full acceptance of the approaches developed appears certain within the next reporting period.

IMPROVING THE MANAGEMENT OF TEXAS RANGELANDS

Concept

Approximately 2 million acres of land in Texas has been designated for use as revenue producing lands for two of the state's universities. The primary source of income from these lands has been from oil and gas, but a major effort is devoted to use of the natural rangeland resources to provide additional revenue. These uses include leasing of the lands for cattle production. This operation requires

careful management to insure maximum use without serious degradation of the resources; an important consideration is the moisture deficient areas of west Texas where these lands are located. It has been hypothesized that the management of these vast range areas could be improved by utilizing remotely sensed data from aircraft and satellite sensors.

Procedure

A NASA Grant applications project initiated in 1971 to examine the role of remote sensing techniques in rangeland management formed the basis for an ERTS-1 investigation which made major strides in defining the capability of aircraft and satellite data for the remote regional determination of range conditions. This work subsequently led to approval of an ERTS Follow-On study which will demonstrate the operational potential of these data for rangeland management in the Great Plains. Throughout this work, the original NASA Grant project has been maintained to complement and expand on the ERTS investigations. The combined efforts have resulted in the development of a rapid, effective spectral signature analysis technique which provides a measure of green biomass on rangelands in the Great Plains throughout the growing season. This quantitative method clearly indicates the influence of spring

rain and summer drought. Such information is extremely important to effective range management in Texas.

Results

The remote sensing technique developed to measure range condition has been presented to the director of the range management program for the Texas state lands, at his request. The procedure and the information obtained satisfy a pressing need of this organization, i.e. to obtain rapid, accurate assessments of the range conditions over the entire management area. In addition, the University of Texas is actively involved in a mesquite eradication program on these lands and they need an effective means of monitoring both the extent of the woody plant encroachment and the effectiveness of their correction procedures. Therefore, an effort is being made to obtain 1976-77 funding from the Texas Legislature to acquire the necessary data and to apply the Remote Sensing Center analysis procedure to assist in the management of these lands. It appears at this time that these funds will be approved during the current session of the Legislature.

Anticipated Payoff

As a result of this NASA Grant project and the related ERTS projects, new rangeland condition assessment procedures have been developed which are directly applicable to current rangeland management problems in Texas. It is anticipated that these procedures will be tested and subsequently adopted for regular use by the state of Texas to improve the management and utilization of the valuable rangeland resources on these controlled state lands.

INCREASING THE PRODUCTIVITY OF CROPS IN TEXAS

Concept

Over 300,000 acres of Texas' agricultural lands are devoted to the production of peanuts. Of the seven principal peanut producing states in the nation, Texas ranks second in total acreage, but last in yield per acre. One of the reasons for this situation is the abnormally severe damage caused by foliar diseases in the Texas crop. It is estimated that the loss due to these diseases exceeds $10 million in Texas. An effective fungicide is available to assist with the control of these diseases, however the current application procedure is unsatisfactory because

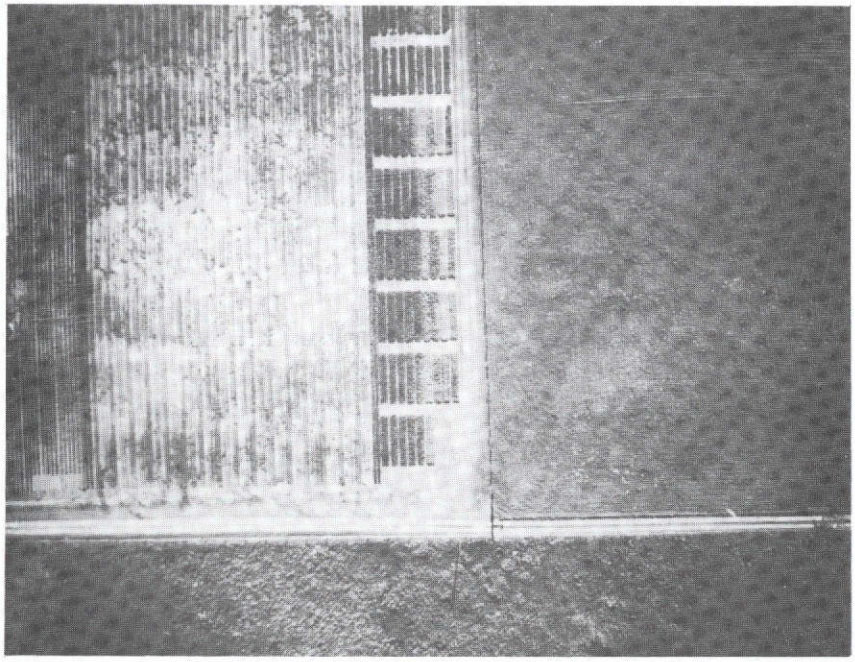
early treatment is essential and there is no present method for detection of the initial disease symptoms except in micro-scale. Remote sensing, if feasible, would provide the timeliness, the areal coverage, and the economy of operation necessary for an effective foliar disease control program.

Procedure

Test plots of peanuts were established on which three separate levels of foliar disease control were to be maintained. This provided three different levels of defoliation rates as the disease became established and, at harvest, three separate yield rates. Peanut yields from the October harvest were measured for each of the three control treatment levels.

An ERTS radiometer was used throughout the growing season to collect spectral signature data for healthy and diseased plants and for ground-level remote monitoring of peanut disease progress. Color infrared photography was used for airborne detection. Radiometer and photographic data were checked with actual defoliation counts after disease onset in September.

Existing pattern recognition and analysis techniques were applied for data analysis in order to determine



FOLIAR DISEASES IN PEANUTS - In the aerial photograph above, healthy and diseased peanuts are differentiable (center strip) as dark and light vegetation. Reflectance values are correlated with yield loss due to leaf spot disease.

The photo at the left shows ERTS Radiometer measurements being taken on leaf spot diseased and healthy peanuts.

19-a

the optimum method for future commercial monitoring work. Raw reflectance data from the peanut canopy were normalized by ratioing against standard panel reflectance readings. Peanut canopy reflectance values were compared between spectral bands, for each of the three control treatment levels, by taking both ratios and differences.

Results

Analysis of ERTS radiometer data and comparison with actual foliage counts indicates a greater than 85 percent probability of correctly distinguishing between the different disease control levels and, thus, different disease-induced defoliation rates and subsequent crop yields. Aerial photos, qualitatively examined, also show clearly distinguishable differences in treatment levels. Analyses of these data established the feasibility of remote sensing use for:

- estimating defoliation and subsequent yield,
- wide-area crop loss surveys, and
- forecasting the optimum timing for fungicide application.

Payoff - Current and Anticipated

As a result of the use of the ERTS radiometer, the Texas Agricultural Experiment Station (TAES) will be using it on the conveyor line to separate peanuts into their four commercial grades. A prototype radiometer-grader has been designed and the completed unit will be used by State and Federal peanut inspectors who now grade peanuts visually.

TAES will put the remote sensing based peanut disease forecasting system into commercial operation in order that timely application of fungicide may be made.

With some further development, ERTS data will be used to provide defoliation and yield loss estimates for the peanut crop, in a manner similar to that anticipated from NASA's LACIE wheat study.

APPLICATIONS

The following projects are applications studies which are either emerging Demonstration Projects or are activities in which the Remote Sensing Center is working with State and Federal agencies on a regular basis to encourage and develop the adaptation of remote sensing techniques to their normal problem-solving activities.

APPLICATIONS OF REMOTE SENSING BY TEXAS STATE AGENCIES

During the last two years, the state of Texas has conducted a vigorous program to introduce remote sensing techniques into relevant activities of the government agencies. This effort has been organized by the Governor's office with the help of the Johnson Space Center, the Bureau of Economic Geology, and the Remote Sensing Center. A special Remote Sensing Task Force has been formed which includes representatives of all the state agencies.

A major part of the overall effort has been the education of state employees in the general principles of remote sensing and in the specifics of data processing using the LARSYS system.

Although several remote sensing application projects have been initiated within different state agencies, two in particular are beginning to take shape with the assistance of Remote Sensing Center personnel funded by the NASA Grant. They are (1) a state-wide wildlife habitat survey based on ERTS-1 data being conducted by the Texas Parks and Wildlife Department, and (2) the use of remote sensing to aid in the coastal zone mapping effort of the Texas General Land Office.

Wildlife is an extremely important economic resource in Texas. Many farmers and ranchers in Texas receive more revenue for game leases than from their agricultural activities. At present the game surveys and wildlife habitat assessments are conducted on the ground by state employees. This process is slow, expensive, and inaccurate. Based upon the results of a NASA Grant project conducted by the Remote Sensing Center in cooperation with the USDA Soil Conservation Service and an independent study by state personnel of the Wildlife Department, it appears feasible to obtain much of the desired information on wildlife habitat using computer analyzed ERTS-1 MSS data. The ERTS-1 data are now being assembled for a pilot project to verify the feasibility of the approach prior to adopting the technique on a regular basis.

The General Land Office is responsible for initiating the coastal zone management plan recently required of the coastal states by the U.S. Congress. Personnel of the Remote Sensing Center met, on request of the General Land Office, with representatives of the several agencies and institutions now working on the coastal zone mapping problem to explain the potential of remote sensing in this application. The Center conducted a preliminary study of the

general problem and prepared a report on "Coastal Zone Monitoring by Remote Sensing: Rationale, System Alternatives, and System Costs" which describes several approaches to using remote sensing to assist in the monitoring and mapping effort and the relative costs of these techniques. The General Land Office is now examining the possibility of incorporating one or more of these approaches into their coastal zone management plan.

LAND RESOURCE MANAGEMENT BY USDA/SCS

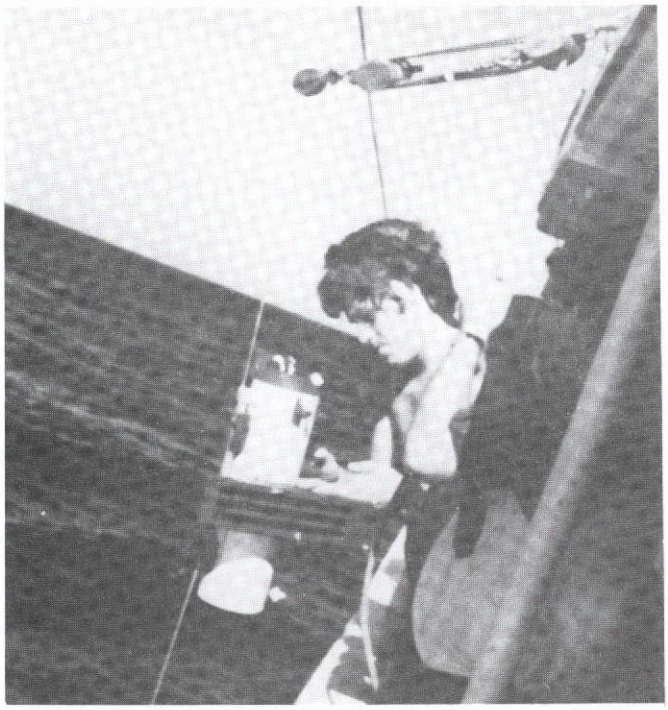
A NASA Grant project has been developed as a cooperative study with USDA Soil Conservation Service personnel to evaluate selected applications of remote sensing for land resource management. Two phases of this project have been completed which included three specific tasks: (1) a study of the relationship between the existing soil survey of Brazos County, Texas and interpretations made from color-IR and other remote sensing imagery, (2) a study of remote sensing technique applicable to the conduct of a standard Conservations Needs Inventory (CNI) for Brazos County, and (3) development of survey techniques for conducting wildlife habitat surveys on a regional basis.

As described earlier, results of the latter task are now being applied in a new Texas Parks and Wildlife

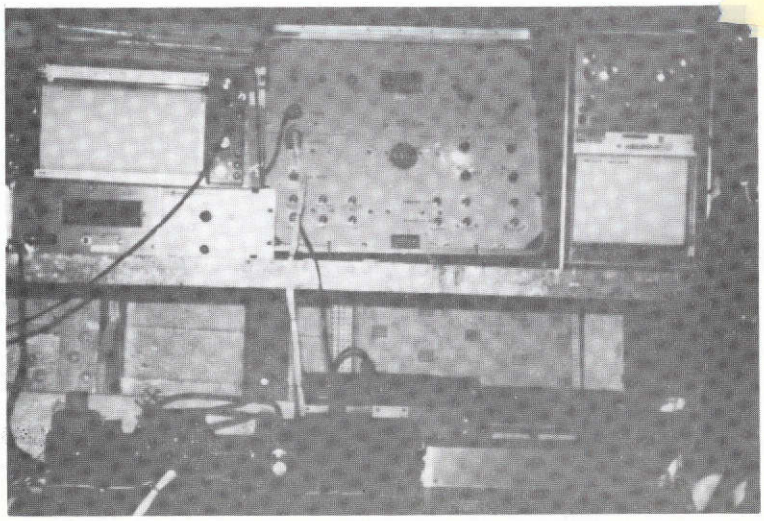
Department activity. The effort on the NASA Grant project during this report period has been devoted to the soil survey aspects of the overall study. Multispectral airborne imagery of Brazos County has been provided by NASA and is being used to establish a technique for rapid, cost-effective delineations of uniform soil landscapes. The analysis employs both soil color and vegetation patterns to obtain the soil landscape boundaries. Successful development of this approach would greatly decrease the time required by the SCS to make available this information to land resources managers and considerably reduce the cost of their operation.

DELINEATION OF AREAS OF HIGH PRODUCTIVITY IN THE OCEANS

A NASA Grant project has been initiated in cooperation with the Cousteau Society, the Goddard Space Flight Center, and the Environmental Protection Agency to establish the feasibility of using remote sensing techniques to delineate areas of high primary production in the oceans. Two members of the Remote Sensing Center staff accompanied Jacques Cousteau aboard the CALYPSO on a four-month cruise which included a wide range of scientific experiments. Preliminary results of this work indicate that is was the most successful coordinated airborne and ocean surface



COUSTEAU EXPEDITION - Remote Sensing Center biologist collecting water samples from the CALYPSO.



25-a

COUSTEAU EXPEDITION - Continuous monitoring instrument console showing readouts for NASA/GSFC two channel scattering meter and NASA/AMES fluorometer.

measurements program yet conducted in this application area. NASA and Texas A&M scientists are finalizing the analysis of the data in anticipation of additional cooperative studies with Cousteau.

MONITORING THE CHARACTERISTICS OF RESERVOIRS IN TEXAS

The State of Texas permits landowners to dam non-navigable streams and impound up to 200 acre-feet of water per pond. The resulting proliferation of private ponds has a substantial downstream impact on the quantity and quality of river flow and of reservoir storage in the total state watershed. The Texas Water Development Board and Texas Water Quality Board are responsible for monitoring the volume and the quality of state waters. With conventional methods, only the larger state reservoirs can be monitored with regularity. Very little is known about the number and distribution of farm ponds, or about their cumulative impact on the total watershed. Remote sensing, on the other hand, can provide an economical method for locating, inventorying and classifying impoundments, both public and private.

For water quality analysis, ERTS data on Texas lakes were exhaustively collected along with corresponding Texas Water Quality Board monthly printouts on the physical and chemical parameters of Texas reservoirs. In those cases where ground truth data were taken a few days before or after a good ERTS overpass, ERTS grayscale maps and digital data were obtained and compared with the TWQB turbidity and chlorophyll measurements.

For inventory and size classification, NASA aerial photography was used. The test strip is from a March 1970 flight path covering the Colorado River Basin from the Gulf of Mexico to New Nexico. A random grid system was used for analysis. Each square examined was classified according to geologic formation, major soil group, distance from a river, road type, habitation density, nearness of ponds to habitation and size category of each pond.

The pond inventory project is now at the point where grid data is being punched on computer cards for subsequent analysis.

The water quality classification project is in the early analysis stage. Preliminary examination shows a workable relationship between turbidity and radiance values for Bands 5 and 6, and between chlorophyll and radiance values for Bands 6 and 7.

Even at this early stage of development, results indicate that the procedures will be viable and that Texas state agencies will benefit substantially from the standpoint of effectiveness as well as economy of operation.

SUPPORTING TECHNOLOGY

The Supporting Technology projects, which initially represented the majority of the NASA Grant activity, have been responsible for several significant results subsequently funded in full or in part from other sources. This general activity area has now been substantially reduced and should be virtually eliminated during the next report period.

MICROWAVE REMOTE SENSING OF SOIL MOISTURE

The Texas A&M University studies have been a significant factor in continuing the development of microwave remote sensing techniques. This field of study had been receiving only limited support from NASA during the ERTS-Skylab era due to the concentration of resources on these satellite programs. Now that attention is again being directed toward the use of microwave remote sensing technique, the small ongoing NASA Grant effort at Texas A&M University has assumed added significance and new funds are being put into this program by NASA/JSC. It is fortunate that a

SOIL MOISTURE MONITORING - Aerial view of NASA/JSC two-frequency radiometer in foreground, University of Kansas radar spectrometer in background, at opposite sides of bare soil plot on TAMU Campus.

28-a

nucleus of activity had been maintained under the NASA Grant so that a solid base existed for the renewed interest in these sensing techniques.

The development by the Remote Sensing Center of a reliable microwave technique to measure soil moisture has evolved steadily through a series of controlled ground-based experiments and model development activities. The effects of soil types, surface roughness, and vegetation cover have been measured and analytical models have been developed and tested. The capabilities and limitations of passive microwave sensing of the soil moisture content in natural terrain have been documented and the encouraging potential has led to an expanded program sponsored by JSC.

APPLIED DATA ANALYSIS

The Remote Sensing Center has conducted a long-term NASA Grant project to develop an interactive data analysis facility to support the analysis of multivariate digital data, such as ERTS-1 MSS data. This is a software/hardware facility which includes a TI 980A minicomputer, color television display, and associated equipment. During this report period, the Interactive Resource Information Management and Analysis System (IRIMAS) development

DATA ANALYSIS FACILITY - Interactive console of the RSC computer-aided digital data analysis system.

has been completed to facilitate the analysis and cataloging of two-dimensional spatial and temporal information required for resource related decision making. This comprehensive data handling system has been tested and employed in one phase of the analysis of the Woodlands vegetation data. This work is described in Technical Memorandum RSC-105, "Resource Evaluation of a Development Site Using IRIMAS" by J. A. Schell.

The interactive data analysis facility has advanced to the stage that major segments of the system have been separated from the NASA Grant program and placed under a separate user-supported account. That is, the facility is now a self-supported independent service of the Remote Sensing Center which operates on a per job charge basis. Development of new application-oriented system software elements will continue as part of the NASA Grant project activity, however this is a minor effort which is being phased-out as a separate activity.

The extent of the separation of the data analysis facility from the NASA Grant is demonstrated by the fact that whereas in January 1975 NASA approved the purchase of $10,000 worth of additional equipment for the facility, the funds were not used. The equipment was purchased from a

capital investment fund (non-NASA funds) established as part of this new user service.

This NASA Grant project is another example of the successful development and transfer of technology from a research mode to an operational applications mode. It further demonstrates the methodology which has been applied in the management of the NASA Grant project at Texas A&M University.

CONCLUSION

This semi-annual progress report clearly establishes that the Remote Sensing Center has successfully transformed the NASA Grant Program from an SR&T mode to an Applications mode exhibiting several successful Demonstration Projects. The report illustrates that the program objectives established by NASA have been totally integrated into the Texas A&M University NASA Grant effort. Further, a close working relationship with several State and Federal agencies, including in some cases funding by these agencies, has been achieved, and that a firm base has been established for additional cooperative activities.

HIGHLIGHTS OF DEMONSTRATION PROJECTS

RECENT PRACTICAL APPLICATIONS IN REMOTE SENSING

developed by

Remote Sensing Center, Texas A&M University

under

NASA GRANT NGL 44-001-001

DEMONSTRATION PROJECTS

- ST. AUGUSTINE DECLINE
- THE WOODLANDS
- AQUATIC PLANT MONITORING

St. Augustine Decline

- CONCEPT

St. Augustinegrass is an important commercial crop that has become infected with a virus (SAD) and is now under quarantine. Use of aerial photography will substantially improve the effectiveness of the state's quarantine program.

St. Augustine Decline

- PROCEDURE

Spectral signatures of healthy-versus-infected St. Augustinegrass were determined. Films and filters were selected for multicamera photography.

A test flight was scheduled over infected commercial fields.

ST. AUGUSTINE DECLINE

- RESULTS

Growers were notified that remote sensing overflights were to take place.

Growers destroyed all SAD-infected grass prior to the scheduled flight.

ST. AUGUSTINE DECLINE

- PAYOFF

Threat of remote sensing surveillance for quarantine enforcement prompted the growers to comply.

Texas Department of Agriculture now has effective method of halting SAD spread.

THE WOODLANDS

- CONCEPT

A "new town", funded under HUD Title VII, must be planned and built for low environmental impact. Remote sensing provides a rapid inventory of the site's vegetation system, greatly simplifying the problem of insuring optimum preservation of the native plant species.

THE WOODLANDS

- PROCEDURE

Large scale color and color infrared photography was taken over the site and sufficient ground work done to verify species and condition.

Vegetation maps were made showing location, species and specimen quality.

THE WOODLANDS

- RESULTS

Maps provided developer with information needed to plot the townsite for optimal environmental preservation.

Sequential photography showed the impact of construction work on vegetation.

THE WOODLANDS

- PAYOFF

Developer reduced his landscaping and artificial drainage costs. Higher land values provide higher profit per acre.

Home buyers benefit from more natural setting, lower cooling costs, landscaping savings and higher resale prices.

AQUATIC PLANT MONITORING

- CONCEPT

Aquatic plants are a serious problem in Texas lakes. Growth is explosive and ground monitoring impossible. Remote sensing provides a way of monitoring species, areal extent of infestation and rate of spread from month to month and season to season.

AQUATIC PLANT MONITORING

- PROCEDURE

Take color and color infrared photos of infested lakes. Ground check for species verification.

Control photographic procedures for color repeatability. Do sequential photography to document seasonal changes.

AQUATIC PLANT MONITORING

- RESULTS

Procedures established for:

- *differentiation between emergent species*
- *areal delineation of all species*
- *precise monitoring of herbicide effects*

AQUATIC PLANT MONITORING

- PAYOFF

Imagery being used for control work.

Follow-on work contracted as an integral part of a 1975 multi-agency study of Lake Livingston, Texas.

Summary of Actions Taken

- ST. AUGUSTINE DECLINE
  Infected fields destroyed by growers.
  Technique adopted for regular use.

- THE WOODLANDS
  Natural environment preserved.
  Technique adopted for regular use.

- AQUATIC PLANT MONITORING
  Dynamics of Texas lake problem documented.
  Technique adopted for regular use.

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